PROPOSAL FOR THE WATER RESOURCES SYSTEMS CENTRE AT THE INDIAN INSTITUTE OF TECHNOLOGY KANPUR

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Proposal for a

WATER RESOURCES SYSTEMS CENTRE

At The Indian Institute of Technology, Kanpur

I INTRODUCTION

Water is one of the basic resources of this planet. It is required in abundance to meet the domestic, agricultural, industrial, and other needs. The ever-increasing population of the world and also higher consumption of water with higher standard of living puts a premium on the economical use of water The availability of water is restricted in various parts of the world. The limitations may be in the availability of water in required quantity and of desirable quality. Over a large part of our nation's water resources are still to be developed. In a developing country like India, where a very large portion of the population depends on agriculture for a living and where other resources like machinery and money are scarce, water conservation and optimal utilisation of the scanty resources is a 'must'.

Civil Engineers have been associated for a long time very intimately with the development of water resources. Evaluation of surface and subsurface water resources, management of water resources problems like droughts, floods, silting, pollution, soil erosion, etc., design of a system of structures for irrigation, drainage, water supply, power, flood-control

etc., and construction, operation and maintenance of the systems are some of the problems frequently handled by a civil engineer. Thus the Civil engineer has been the ultimate authority on the technical features of water resources systems.

In the last decade, there has been a realisation in several parts of the world that, in addition to Civil Engineering several other areas of study are also important in the development of water resources of a region or a nation. They include natural sciences like geography, geology and meteorology, and social sciences like Economics, Sociology, Political Science and Law Water resources development involves public expenditure of a large magnitude from capital raised by public and private agencies. As a national resource, water should be used for the greatest common welfare The criterion of value judgement for different uses of water at different regions is a basic problem for socio-economists, and is an essential prerequisite for optimal water resources development. Thus water resources development is an inter-disciplinary area where Civil Engineers, natural and social scientists have to work together as an integral group to define criteria for resource development with due attention to the social, economic, legal and political aspects of water resources management.

As he is deeply involved in the development of the water resources systems, the Civil Engineer will continue to have a very great responsibility and authority for technical decisions. But he will have to take recourse to help and

advice from natural and social scientists at different stages of his activity. Similarly, natural and social scientists should be familiar with the inter-disciplinary aspect of the problem. This will facilitate the easy communication of ideas among the several members of the team. It is especially so for the engineer, who has to convey to the management the engineering requirements of the system, and the anticipated consequences of alternative policy decisions This will also give him necessary background and training for assuming management positions in the area of water resources development - a type of training generally found lacking in a conventional engineering programme. Opportunity for education and training in water resources with an inter-disciplinary perspective is hardly available to natural and social scientists. But they have a lot to contribute to the optimal development of water resources of India. A Water Resources Systems Centre as envisaged in this report will give the necessary fillip in this direction.

II. WATER RESOURCES EDUCATION

As water resources development deals with the optimal development of complex engineering systems in a socioeconomic environment, a great scope exists for the use of management techniques in the optimal utilisation of materials, machinery, money and men. Thus water resources education should be with an inter-disciplinary perspective and management-oriented in order to train specialists in this field who will be aware of the requirements of any given region, and who can work as

members of an inter-disciplinary team in order to develop optimally the water resources of the region. The techniques that will be learnt in such a programme will be broad-based. They can be used for the comprehensive development of a single river basin or several river basins in a given region.

Conventional graduate programmes in individual areas of geology, geography, meteorology, economics, and hydraulic engineering are available in India in a large number of universities. The Water Resources Development and Training Centre (WRDTC) at Roorkee also has a good programme for training engineers in this area. There is, however, a very great demand in India for a Water Resources Systems Centre that will be able to offer a programme of study and research in the area of water resources with special emphasis on the inter-disciplinary nature and on optimal utilisation of water and other scarce resources of the nation.

The activities of the proposed Centre will involve:

(1) coordination of courses offered by the several departments of the Indian Institute of Technology Kanpur (IITK), in the area of water resources,

(2) offering courses by members of faculty attached to the Centre in areas not represented in the other departments,

(3) conducting and coordinating research in the area of water resources,

(4) developing a water resources data library to facilitate research, development and design,

(5) establishing and maintaining special Water resources laboratories, and

(6) conducting conferences, intensive courses and special programmes of study and training in the area of water resources

Departments which will participate actively in the Programme

(1) Civil Engineering:
   (a) Hydraulics and Water Resources section
   (b) Sanitary engineering section

(2) Humanities and Social Sciences
   (a) Economics section
   (b) Sociology section

(3) Mathematics
   (a) Operations Research group

(4) Mechanical Engineering
   (a) Industrial engineering section

(5) Electrical Engineering
   (a) Systems group
   (b) Instrumentation group
   (c) Computer Centre

Master's and Ph.D. programmes will be available under this programme. Some of the courses that will be taught are shown in Appendix - 1.

III. WATER RESOURCES DATA LIBRARY

Water resources data in India are scanty. Further, they are not available from a single source. For example, rainfall and meteorological data are available from India Meteorological Department (I.M.D.); topographic and other maps are available from the Survey of India (S.I.) and the Geological Survey of India (G.S.I.); runoff records are available from Central Water and Power Commission (C.W.P.C.), state governmental organisations like Public Works Department (P.W.D.), and Irrigation Department; whereas the ground water records are available from the Geological Survey of India, Exploratory Tubewells Organisation, and several other fragmentary sources There is a very great need to collect correlate, and store such information in one or more centres which can also update the data as and when they come in.

The types of data that are important for the design of water resources systems include:

(1) Topographic data,

(2) Geographic data,

(3) Geological data,

(4) A. Hydrometeorological data:

(a) Precipitation,

(b) Streamflow, Soil erosion and Sediment load,

(c) Temperature, Wind, Solar radiation etc.,

(d) Evaporation and Transpiration,

(e) Infiltration,

B Ground Water Data:

(a) Water levels in aquifers,

(b) Transmissibility, Storage Coefficient and other Aquifer data, etc.,

(5) Water quality (Chemical and Bacteriological data),

(6) Water utilisation data:

Demand for water for

(a) Agriculture,

(b) Domestic and Industrial water supply,

(c) Power generation,

(d) Navigation,

(e) Recreation and other purposes,

(7) Economic data:

(a) Cost of different types of structures and systems,

(b) Benefits for different purposes in different places for different levels of development,

(8) Demographic data,

(9) Data for different river basin projects

(a) Investigation,

(b) Design,

(c) Research, and

(d) Progress and operational reports.

One of the important sections of the proposed WRSC is a Water Resources Data Library The function of the Data Library is to collect, compile and organise the requisite data for the research projects of the WRSC from existing sources such as IMD, CWPC, etc

Data Organisation Project

Data organisation becomes important whenever the data to be handled are large and varied as in the case of water resources. Water resources problems are multifaced covering a broad spectrum of evaluation and optimal multipurpose utilisation of the resources. Each problem requires different combinations of water resources data peculiar to the problem. Hence an efficient organisation of storing and retrival of data is very important. As such a scheme is not available at present, it is necessary to develop a methodology for the same.

It is proposed to have a Water Resources Data Organisation project with a view to:

(1) conduct a detailed survey of water resources data that is already available and is being collected by different organisations in India, with particular reference to its variety, extent and reliability, etc.

(2) formulate and develop "information systems" for efficient storage and retrival of water resources data, on the basis of the availability, use, value of data, etc., and

(3) establish the validity of the above mentioned information systems by testing with data from one or more river basins,

(4) serve as a pilot project and nucleus for future data organisation programmes in India.

Once such a scheme for storage and retrival has been developed, it is necessary to put it immediately into practice on a national scale This requires th t the Government of India should establish national and/or several regional Water Resources Data Centres which will collect the data from existing organizations like IMD, CWPC, etc.; store, update and disseminate the data to the different users on the basis of the information systems developed as indicated above.

From the experience gained by the implementation of such a system of data organisation, it may be necessary to improve the system procedures. In order to ensure continuity of thought, dynamic interaction between the faculty of the WRSC and to facilitate continuous updating of the information systems, it is necessary that at least a regional Water Resources Data Centre be located in Kanpur. Further, the data library facilities developed at IITK as part of the above-mentioned data organisation project may be utilized for establishing the data centre at Kanpur.

IV. COMPUTING FACILITIES AVAILABLE

It is needless to say that a Water Resources Centre with a programme of teaching, research, and development will need the facilities of fast electronic computers. The Indian Institute of Technology Kanpur has the advantage of having the best computing facilities among all the educational institutions in India. The computing facilities available at IITK include:

Digital Computers

IBM 7044

This is a binary word machine with a basic cycle of 2 micro-seconds/word. It has a memory capacity of 32,768 words. The system can read punched cards at 800/min., and punch out at 250/min. The on-line printer prints 130 character lines at 600 lines per min.

IBM 1401

This machine is being used for Input/Output for the IBM 7044. It can also be used as a stand-alone system.

IBM 1620

This machine can store 20,000 digits at one time and can reach any digit in 20 micro-seconds. It can read punched cards at the rate of 250/min., punch at 125 cards/min. and read or write magnetic tape at 20,000 characters per second.

Analog Computers

Three TR-20 computers each having the following specifications are available:

20 operational amplifiers
8 integrator modules
2 quarter square multipliers
1 squarer
1 variable diode function generator
24 coefficient potentiometers

A number of other analog computers are also available.

V. CENTRAL LIBRARY FACILITIES AVAILABLE

One of the main requirements of education and research is a good research library. Within a short span of about 10 years the library at IITK has been able to acquire more than 100,000 volumes, which include, besides technical and scientific literature, a considerable amount of literature on humanities and social sciences as well. More than 12,000 additional publications are being added each year to this collection. Nearly 1300 periodicals are being subscribed for. This has been possible by the collaboration with the Purdue University libraries through the Kanpur Indo-American Program (KIAP).

VI. FACULTY AVAILABLE AT IITK

An inter-disciplinary field like water resources requires participation by faculty from various departments. Graduate programmes leading to M.Tech. and Ph.D. degrees are currently available in the areas of Hydraulics and Water Resources Engineering, and Sanitary Engineering. The experience and research interests of the members of the faculty in these areas are listed in Appendix - 2.

The other important disciplines are, Economics, Sociology, Industrial Engineering (including management), and Applied Mathematics. The Humanities Department has an active Doctoral programme. The Mechanical Engineering Department has recently started an Industrial Engineering section. The Economics faculty which will be playing an important part requires to be strengthened.

In the optimal utilization and management of water resources of a region or in the comprehensive development of a river basin, operation research techniques are employed. The mathematics department at IITK has a strong group in Operations Research with active Doctoral programmes.

The faculty of Civil Engineering Department at IITK, in the area of water resources has been actively involved in research activities. A list of research publications in the area of water resources engineering by the faculty is presented in Appendix - 3.

VII. SOME TYPICAL WATER RESOURCES PROBLEMS DESERVING STUDY

Identification of Problems

Optimal water resources development requires meteorological, hydrologic, ground water, topographic and socio-economic data. In India, the hydrologic data are limited with reference to the length of time for which they are available, the density of hydrologic net works, the paucity of several types of data (such as infiltration, soil moisture, ground water, consumptive losses, etc.) and the quality and reliability of such data. In a developing economy, there are several critical problems involved in the evaluation of benefits and costs of water resources systems due to lack of methodologies to quantify the social values. Further, reasonably accurate procedures are not available for quantitative evaluation of the surface and subsurface water resources of river basins. It is desirable and seems feasible that the limited data available can be more efficiently used to develop methodologies for better estimation and management of water resources.

It is proposed to take up an intensive project for development of techniques for

(1) evaluation of surface and subsurface water resources. In India, the available amount of concurrent rainfall, run off, ground water, and other hydrometeorological data is very limited. It is possible to formulate mathematical or conceptual models of river basins using these data. These models can then be

employed with the extensive rainfall and other meteorological data to estimate surface and subsurface water resources of basins which do not have proper runoff data.

(2) the analysis of problems like soil erosion, droughts, floods, sedimentation in streams and silting of reservoirs, water quality, water logging, etc. and

(3) development of procedures for optimal utilisation and management of water resources. The study will be conducted for one or more specific regions in India (e.g. Ramganga basin, U.P., Upper Gangetic Basin etc.) The studies will be general enough to be used with minor modifications for other regions or basins Since water resources development is a perennial problem, this project will only be a first step in a continuous dynamic programme of research in this very essential field.

Evaluation of Water Resources of a Basin

The surface water resources directorate and the Geological Survey of India are the appropriate agencies of the Government of India which deal with evaluation of the water resources of Indian rivers They have completed, or are at present in the process of completing, evaluation of water resources of several regions or basins. Because of their specific responsibilities the former are interested in surface water, while the latter deal with ground water. The problems facing them are immense, as they have to estimate the water

resources in the absence of reliable and extensive hydrometeorological data.

In the last decade several new techniques have been developed in U.S.A., Russia, and other developed nations to estimate the water resources of a basin in a better way. These include detailed water budget models for predicting surface runoff, ground water storage, and ground water runoff by multiple correlation techniques on a day to day basis and the use of simulation models Examples are that of Stranford Watershed model, Kohler model etc. A general model will be used which includes both surface water and ground water as primary components The model will be employed to test several empirical hypotheses concerning the components of the system and the evaluation of suitable coefficients on the basis of the available concurrent rainfall, runoff, ground water and other hydrometeorological data. It may be possible to develop a distributed parameter system model for the basin(s) to indicate the system variability in space. This model will be used next for simulating the river basin(s) using the longer daily historical hydrometeorological data to estimate streamflow and ground water storage. The third step will involve formulation of stochastic models for daily precipitation and hydrometeorological factors of the basin, generation of sequential data and subsequent simulation of the basin to estimate long term variations of surface and ground water runoff. The study will include hydrologic design of surface and ground water systems.

Analysis of Water Resources Problems

Some of the water resources problems are droughts, floods, sedimentation, water quality, water logging, soil erosion etc. A study will be undertaken for the basin under consideration to estimate droughts on the basis of hydrometeorological data and soil-plant-water relationship. Flood control is an important problem in any river basin. In India, the hydrologic data available are very limited and especially the length of data for flood runoff in several small and medium basins is usually small. It is hence proposed to develop systematic procedures for estimating floods in basins with fairly long precipitation data (say 25 years or more) and limited flood runoff data. The study will involve formulation of (i) stochastic models for extreme storm precipitation and abstraction, (ii) hydrologic system models (including distributed parameter, non-linear system models), by sequential generation of storm precipitation data, and simulation of floods. The study will also involve hydrologic design of flood control systems.

It is necessary to conduct periodical sedimentation survey of the selected river basins using sophisticated instruments like echo-depth recorder, tellueurimeter etc., and on the basis of other available sediment data, if any, estimate the seriousness of the problem of sedimentation and its influence on the design of the channel systems and reservoirs.

Problems in the area of ground water include water quality, water logging, salt encrustation, mining, etc. Where such problems are prevalent or are expected in the absence of remedial measures, they can be studied by use of extensive models of the basin. The parameters of such a system can be estimated on the basis of historical data on rainfall, ground-water, stream flow, irrigation, pumpage etc. Remedial measures may be tested on such models and when found satisfactory can be adopted with confidence.

Soil conservation problems such as soil erosion, soil salinity and soil moisture movement also require detailed study. Plant-water relationships, field application of water and water-shed protection and management are important areas for efficient utilisation of water resources of a predominantly agricultural nation like India. However, extensive research in this area is not being currently planned in WRSC particularly in view of the following facts:

(1) They are being conducted in an elaborate way in the Water Technology Centre of the Indian Agricultural Research Institute (IARI) and the agricultural universities, and

(2) It is contemplated to collaborate with the above agencies and also local organisations such as IARI field centre, Kanpur, the proposed Agricultural University, Kanpur, and U.P. State Agriculture Research Station, Kanpur.

Optimal Design of Water Resources Systems

A water resources system consists of an ordered assemblage of interacting system units for single or multiple purpose utilisation of surface and/or ground water resources. Modern water resources projects often constitute very complex systems which may be created through different combinations of system units (reservoirs, power plants, canals, etc.), levels of output (capacity), and allocation of the units to various complementary or competitive purposes (irrigation, flood control, power generation, etc.) at different times. The system variables include the arrangement, number and type of units, their capacity, and the allocation of each unit for the various purposes at different times.

The project formulation, i.e., decisions concerning the system variables, constitutes the system design. The system design may be subject to technical, budgetory, social or political constraints. The objective of water resources development and resources-utilisation is to be precisely expressed in terms of economic efficiency, income redistribution, famine prevention, regional development, etc. The criterion for system design is to select from among the large number of multiple alternatives, the one which, while satisfying the constraints, performs best on the basis of the given objectives. Such a design is referred to as "Optimal design".

Water resources systems are subject to the vagaries of nature and the fluctuations of the national economy. Optimal design of water resources systems cannot be accomplished by conventional techniques because of the complexities inherent in the problem like multiple alternatives, problems in economic evaluation of the benefits, and the stochastic variation of hydrologic data. Because of their speed and ability to solve complex problems, digital computers are very frequently used in optimal design of complex engineering systems. Several techniques generally referred to as "Operations Research" techniques are used in optimisation problems. They include programming models like linear, non-linear, dynamic programming, and simulation techniques.

It is hoped that as a result of the activities of WRSC, a methodology for a continuously evolving river basin planning programme may be developed here and used in planned optimal utilisation of our nation's resources.

VIII. ADDITIONAL FACULTY REQUIRED

There is an intimate interaction between the economic and engineering considerations in the optimal development of water resources of a river basin or a region in general. Neither discipline can contribute its share to an optimal design without the collaboration of the other. There is a strong group already at IITK in the Engineering discipline. However, the economics section in the Humanities Department requires to be strengthened. The type of economists who will play useful part in this programme will be econometricians, mathematical economists and welfare economists. Additional faculty needed in economics as well as in engineering is given in Appendix - 4.

In the efficient water management, modern management techniques like linear, non-linear, dynamic programming, simulation techniques, etc., play a vital role. This is an area in which this country lacks generally. When the amount involved runs into billions of rupees as it does in big complexes as the water resources projects, efficient management becomes even more important. In IITK, management-oriented programmes are available in several areas such as industrial engineering. Faculty from these areas may participate in the activities of the proposed Water Resources Systems Centre.

Watershed management is necessary for control of soil erosion and conservation of water resources. A Soil-Water Conservationist will play a useful role in this respect.

Guest lecturers may be invited to deliver lectures in the areas like water resources law, geographical aspects, public administration, etc.

IX. SPECIAL LABORATORY FACILITIES REQUIRED

The available laboratory facilities at IITK are shown in Appendix - 5. However, the proposed Water Resources Systems Centre requires special laboratories such as:

1) Indoor and outdoor water resources laboratories: These involve facilities necessary for

   (a) measurement and analysis of evaporation, infiltration, soil moisture movement,

   (b) outdoor experiments on studies of Watershed runoff and infiltration, and

   (c) Watershed simulation systems

2) Representative Watershed programmes for small and medium Watersheds: Equipment is required for intensive instrumentation fo detailed investigation of hydrologic processes in small and medium watersheds.

3) A Hydrometeorological station: This is being set up by the department of Civil Engineering. Details of the equipment available are shown in Appendix - 5. Additional equipment are necessary to improve the existing facilities.

A list of additional equipment required is presented in Appendix - 6.

X. ESTIMATED COST OF THE PROPOSED WATER RESOURCES SYSTEMS CENTRE

The activities of the proposed Water Resources Systems Centre have been given in the previous sections. These are teaching, research and development. Water Resources education has assumed a great importance in India because of the magnitude of the amount spent on water resource development of the country. The type of education that is envisaged by the Centre is not available in the country at present. Water resources engineers trained in management or operation research techniques will play a dominant role in the economic development of this country.

In order to achieve this goal additional faculty as given in Appendix - 4 is needed. The yearly expenditure involved is given in Appendix - 7.

As a part of water resources education, water resources research is also to be undertaken by the proposed Centre. Without research and developmental activity, teaching becomes static For a dynamic programme of teaching, a dynamic programme of research and development is a 'must'. In section VII, a brief description of some of the problems proposed to be undertaken has been mentioned. These problems are, in particular, oriented to meet the requirements in optimal development and utilization of the water resources of India.

The problems to be undertaken, of course, will vary according to the knowledge available at any time. So future

problems depend on the progress of research and also on the needs of the country at the time. Students working for degrees of Master of Technology (M.Tech.) and Doctor of Philosophy will be working on these projects. However, supporting staff of various categories will be needed. Also the M.Tech. and Ph.D. students will be given financial assistance to attract good students. An estimate of yearly expenditure in this regard is shown in Appendix - 7.

It was mentioned in section IX that special laboratories are required in the proposed Water Resources Systems Centre. An estimate of expenditure on this is also shown in Appendix - 7.

The total estimated cost for the proposed Centre is Rs. 5.76 million for a period of five years.

XI. SCHEME OF ORGANISATION

The activities of the proposed Centre will be coordinated by a Coordinator. He will be assisted by a committee of 8 members. The Head of the Department of Civil Engineering and the Institute nominee will be ex officio members of the committee The remaining 6 members will be the group leaders representing various areas of Water Resources, such as Hydrology including meteorology, Ground Water and Soil Sciences, Economics and Social Sciences, Systems Analysis, Water Quality Management, Hydraulics and Fluid Mechanics, etc Appendix - 8 shows the scheme of organisation.

The Coordinator will be in the overall charge of the Centre. His main duties will be (1) planning and management of the Centre (2) preparation of the budget (3) recruitment of the personnel to the Centre. In these duties he will be assisted by the committee mentioned above.

In the initial period the WRSC will be a part of the Civil Engineering Department at IITK. The Coordinator of the WRSC will be responsible to the Head of the Civil Engineering Department.

XII. CONCLUSION

In conclusion, it is emphasised that opportunities for education and training in water resources with an inter-disciplinary perspective is hardly available in India. Thus, there is a need in the country for a good Water Resources System Centre as envisaged in this report. In such a centre, engineers and scientists from several disciplines such as engineering, humanities and social sciences, work together as an inter-disciplinary unit, to define criteria for water resource development with due attention to the social, economic, legal, political and technical aspects of water resources management. It is proposed to develop methodologies for the optimal design of water resources systems using programming and simulation techniques. It is firmly believed that such studies will give a deeper insight into the complex problem of water resources allocation and utilization and will lead to economic development and utilization of the water resources of the country.

APPENDICES

APPENDIX - 1

COURSES SUGGESTED FOR WATER RESOURCES EDUCATION PROGRAM

1 Available Courses

A) Undergraduate Courses:

CE	411	Hydraulics
CE	412	Water Resources Engineering I
CE	513	Water Resources Engineering II
CE	514	Hydraulic Structures
CE	550	Systems Approach in Civil Engineering
CE	562	Sanitary Engineering II
CE	591	Construction Planning and Management
H-Soc	426	Analysis and Management of Systems
H-Eco.	433	Economic Development and Planning
H-Soc	523	Sociology of Development
MATH	571	Operations Research I
MATH	572	Operations Research II

B) Graduate Courses.

CE	611	Fluid Mechanics
CE	612	Open Channel Hydraulics
CE	613	Sediment Transport
CE	614	Hydrologic Analysis and Design
CE	615	Ground Water Hydrology

CE	616	Water Resources Engineering
CE	618	Ground Water and Seepage
CE	634	Subsurface Geophysical Exploration
CE	650	Numerical Analysis in Engineering
CE	664	Design of Water and Waste Water Systems
MA	770	Mathematical Programming I
MA	771	Mathematical Programming II
MA	773	Inventory Theory
MA	774	Dynamic Programming and Control Process
H-Soc	726	Urban Sociology
H-Eco	732	Econometrics

2. Proposed Courses -

A) Undergraduate Level:

H-Eco	Engineering Economics
H-Law	Water Policy and Legal Aspects

B) Graduate Courses:

CE		Water Quality in Water Resources Development
CE	617	Planning and Development of Water Resources
CE	642	Geomorphology
CE	671	Water Resources Use and Management (River Basin Management)

APPENDIX - 2

FACULTY OF THE DEPARTMENT OF CIVIL ENGINEERING INVOLVED IN WATER RESOURCES AREA

G.D. Agrawal	- Associate Professor Ph.D. (Berkeley) - Assistant Engineer, Irr. Dept., U.P. - Water pollution and water resources (Quality).
K V.G.K. Gokhale	- Assistant Professor, Ph.D. (Kharagpur) - Lecturer, IIT-Kharagpur - Geotechnical Sciences, engineering geology
V. Lakshminarayana	- Assistant Professor, Ph.D. (Harvard) - Assistant Professor, Houston University - Water resources and soil mechanics.
A.V.S. Prabhakara Rao	- Associate Professor, Ph.D. (Bombay) - Assistant Professor, Washington University, St. Louis, Missouri - Research Director, Manufacturing Chemists' Association's Project - Environmental and sanitary engineering, applied microbiology.
S. Ramaseshan	- Assistant Professor, Ph.D. (Illinois) - Lecturer and Assistant Professor, A.C. College of Engineering and Technology, Karaikudi, Madras - Hydrology and water resources engineering.
K K. Rampal	- Lecturer, M.Sc. (Delhi) P G. Dip. in Photointerpretation (Netherlands) - Survey of India - Surveying, photogrammetry, and mapping.

B.C. Raymahashay	- Lecturer, Ph.D. (Harvard) - Research Associate (Princeton) - Research Associate I.I.Sc. Bangalore - Engineering Geology, Water Chemistry.
P.B.S. Sarma	- Lecturer, Ph.D. (Purdue) - Associate Lecturer, Reg. Engg. College, Warangal - Hydrology and Water Resources Engineering
R.H. Siddiqi (on leave)	- Assistant Professor, Ph.D.(Illinois) - ResearchAssociate, University of Illinois - Sanitary engineering, Industrial wastes treatment.
K.S. Singh (on leave)	- Lecturer, M.E. - Assistant Engineer, PWD - Lecturer, College of Engineering, Jabalpore - Photogrammetry and surveying.
K. Subramanyi	- Assistant Professor, Ph.D. (Alberta) - Senior Research Assistant, IISc. Bangalore. - Senior Fellow, University of Roorkee - Hydraulics and fluid mechanics
S. Surya Rao	- Assistant Professor, Ph.D, (Iowa) - Hydraulics, fluid mechanics.

APPENDIX - 3

LIST OF RESEARCH PUBLICATIONS BY FACULTY IN THE AREA OF WATER RESOURCES*

1. Yang, F.C., and V. Lakshminarayana: "Mathematical simulation of water movement through unsaturated nonhomogeneous soils", Soil Science Society of America, Proceedings, 32, 1968.
2. Ramaseshan, S: "A stochastic analysis of rainfall and runoff characteristics by sequential generation and simulation", Ph.D. thesis, Univ. of Illinois, Urbana, Illinois, 1964.
3. Chow, V.T. and S. Ramaseshan: "Sequential generation of rainfall and runoff data", Journal of the Hydraulics Division, Proc. ASCE, Vol. 91, No. HY 4, pp. 205-223, July, 1965.
4. Chow, V.T and S. Ramaseshan: "Sequential generation of rainfall and runoff data by stochastic analysis", Civil Engineering Studies, Hydraulic Engineering Series, No. 11, October, 1965.
5. Ramaseshan, S: "Computer simulation of floods", Computer Society of India, Annual Conference, Trivandrum, 1968.
6. Ramaseshan, S: "Operations research in optimal water resources system design", Golden Jubilee Symposia of Central Water and Power Research Station, Poona, 1966, Vol. II, pp. 175-184.
7. Ramaseshan, S: "Simulation analysis for the estimation and control of floods", presented at the technical session on "Flood Estimation and Control", Annual General Body Meeting, Institution of Engineers (India) Kanpur Sub-centre, 1969

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*This list does not include research publications of the members of faculty from the Sanitary Engineering section.

8. Ramaseshan, S., "Systems approach in civil engineering design", Notes of lectures, Department of Civil Engineering, I.I.T., Kanpur, 1969.

9. Rampal, K.K., "Land resources assessment from aerial photographs", Proceedings of Symposium on Soil Surveys and Land Resources Development, April, 1969, Indian Photo-Interpretation Institute, Dehra Dun, U.P., also in Journal of Institution of Surveyors (India), Kashmir House, New Delhi, in issue of Nov. 1969.

10. Rampal, K.K: "Remote sensing and Tthermal mapping", Eighth Technical Meeting, Institution of Surveyors (Ind.), (to be published June 1970).

11. Raymahashay, B.C. "A geochemical study of rock alteration by hot springs in the paint pot hill area, yellowstone park", Geochim Cosmochim Acta, Vol. 32, pp. 499-522, 1968.

12. Raymahashay, B.C., and H.D. Holland: "Composition of aqueous solutions in equilibrium with sulfides and oxides of iron at 350°", Science, Vol. 162, pp. 895-896, 22 Nov. 1968.

13. Sarma, P.B.S. "Effects of urbanization on runoff from small watersheds", Ph.D. thesis, Purdue University, Jan. 1970.

14 Sarma, P.B.S., J.F. Delleur and A.R. Rao: "A program in urban hydrology: Part IT. An evaluation of rainfall runoff models for small urbanized watersheds and the effect of urbanization on runoff" - Tech. Report No. 9, Purdue Univ. Water Resources Research Centre, Lafayette, Indiana, U.S.A., October 1969.

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APPENDIX - 4

Additional Personnel Required

1. Faculty Positions:

Faculty members with specialisation in the following areas are suggested for recruitment.

Area	No. of Persons
Surface water hydrology	1
Ground water hydrology	1
Economics and Management	2
Soil conservation	1
Geophysics	1
Meteorology	1
System Analysis	1
River Engineering	1

2. Research Associates 3

3. Research Assistants

Senior Research Assistants	(S.R.A.)	7
Junior Research Assistants	(J.R.A.)	14

(These include 6 teaching and technical assistants two of whom are at S.R.A. level).

Area	No.of Persons
4. Laboratory Staff:	
Foreman	1
Senior Tech. Assistants	3
Junior Tech. Assistants	5
Mechanics	3
Laboratory Attendants	4
5. Office Staff:	
Typist-cum-clerk	3
Draughtsman	1
Attendent	1

APPENDIX - 3

EXISTING LABORATORY FACILITIES AT IITK

I. Laboratories

(1) Hydraulic laboratory

(2) Hydrometeorological station and outdoor laboratory (being established)

(3) Fluid Mechanics Laboratory (Mech. Engg. & Aero. Dept.)

(4) Geology laboratory

(5) Survey and Photogrammetry Laboratory

(6) Sanitary Engineering Laboratory

(7) Airstrip and airplanes that may be used for hydrometeorological studies and cloud seeding experiments.

(8) Communication and Image processing laboratories that may be developed for radar observations, and information gathering and dissemination.

(9) Analogue computer laboratory useful in modelling and simulation of hydrologic systems

(10) Other laboratories in the areas of fluid mechanics and heat transfer

(11) Other laboratories like measurement, precision shop etc.

II. Centralised facilities (used in common by several departments)

(1) Central Instrumentation Laboratory:

Repair, calibration and modification of electronic instruments, repository of electronic instruments for loan.

(2) Graphic Arts:

Printing-lithography (offset), letter press: duplicating; slides, photographic reproduction; drawing and design work.

APPENDIX - 6

ADDITIONAL LABORATORY FACILITIES REQUIRED.

1. Indoor Laboratory

   General equipment and facilities.

   a. Experimental systems for simulation of rainfall, overland flow, channel and basin storage, groundwater etc. including physical, electrical, and electronic analogues. Rs.5.0 Lakhs

   b. Watershed simulation system Rs.1.5 Lakhs

   c. Additional facilities for studies in sedimentation. Rs.1.0 Lakh

   d. Soil moisture equipment Rs.0.5 Lakhs

2. Outdoor Laboratory

   a. General equipment for outdoor laboratory and hydrometeorological station including instrumentation for accurate measurement and recording of hydrometeorological factors including rainfall, runoff, infiltration, evaporation, soil moisture measurement, water quality, and groundwater; storm radar tracer techniques Rs.10.0 Lakhs

   b. Rainulator for field measurement of infiltration, a moble facility. Rs.1.0 Lakh

   c. A mobile tubewell testing facility Rs.2.0 Lakhs

3. Representative Watershed Programme

   Intensive hydrologic instrumentation of a small and medium watershed for evaluation of surface and groundwater resources variability and problems. Rs.2.0 Lakhs

4-	Geophysical laboratory	Rs.5.0 Lakhs
5.	Surveying Laboratory	Rs.2.0 Lakhs

APPENDIX -

Abstract of Estimate for the Proposed Water Resources Centre

A. Nonrecurring Expenditure

S.No.	Description	Amount in Rupees (in Thousands) I Yr.	II Yr.	III Yr.	IV Yr.	V Yr.
1.	Laboratories	200	500	1000	1000	500
2.	Furniture and Fittings	50	50	50	50	-
3.	Books and Periodicals	50	100	100	50	50
4.	Miscellaneous	25	50	50	50	50
B.	Recurring Expenditure					
1.	Personnel	100	200	375	375	375
2.	Publications, Operations, etc.	5	10	25	25	25
3.	Stationary, Contingencies, etc.	50	50	50	60	60
	Total:-	480	960	1650	1610	1060

TOTAL FOR 5 YEARS: Rs. 5,760,000/- Only.

SCHEME OF ORGANISATION PROPOSED FOR THE WATER RESOURCES SYSTEMS CENTRE

COORDINATOR

Representative of the Indian Institute of Technology Kanpur

Group leaders (6 members)

Representative of the Civil Engineering Department

The group leaders are representatives of areas such as:

1. HYDROLOGY	including meteorology, hydrologic instrumentation, surface water hydrology, hydrologic systems, etc.
2. GROUND WATER AND SOIL SCIENCES	including ground water hydrology, geophysics, geology, soil mechanics, soil physics, etc.
3. ECONOMICS AND SOCIAL SCIENCES	including economics, sociology, law, public administration, etc.
4. SYSTEMS ANALYSIS	including mathematics, computer sciences, optimization, control systems, etc.
5. WATER QUALITY MANAGEMENT	including sanitary engineering, geochemistry, etc.
6. HYDRAULICS AND FLUID MECHANICS	including irrigation and drainage, river engineering, hydraulic structures, etc.